U.S. Contribution to the Indian Ocean Tsunami Warning System

Recent Tsunami Detection Developments

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NDWC Briefings

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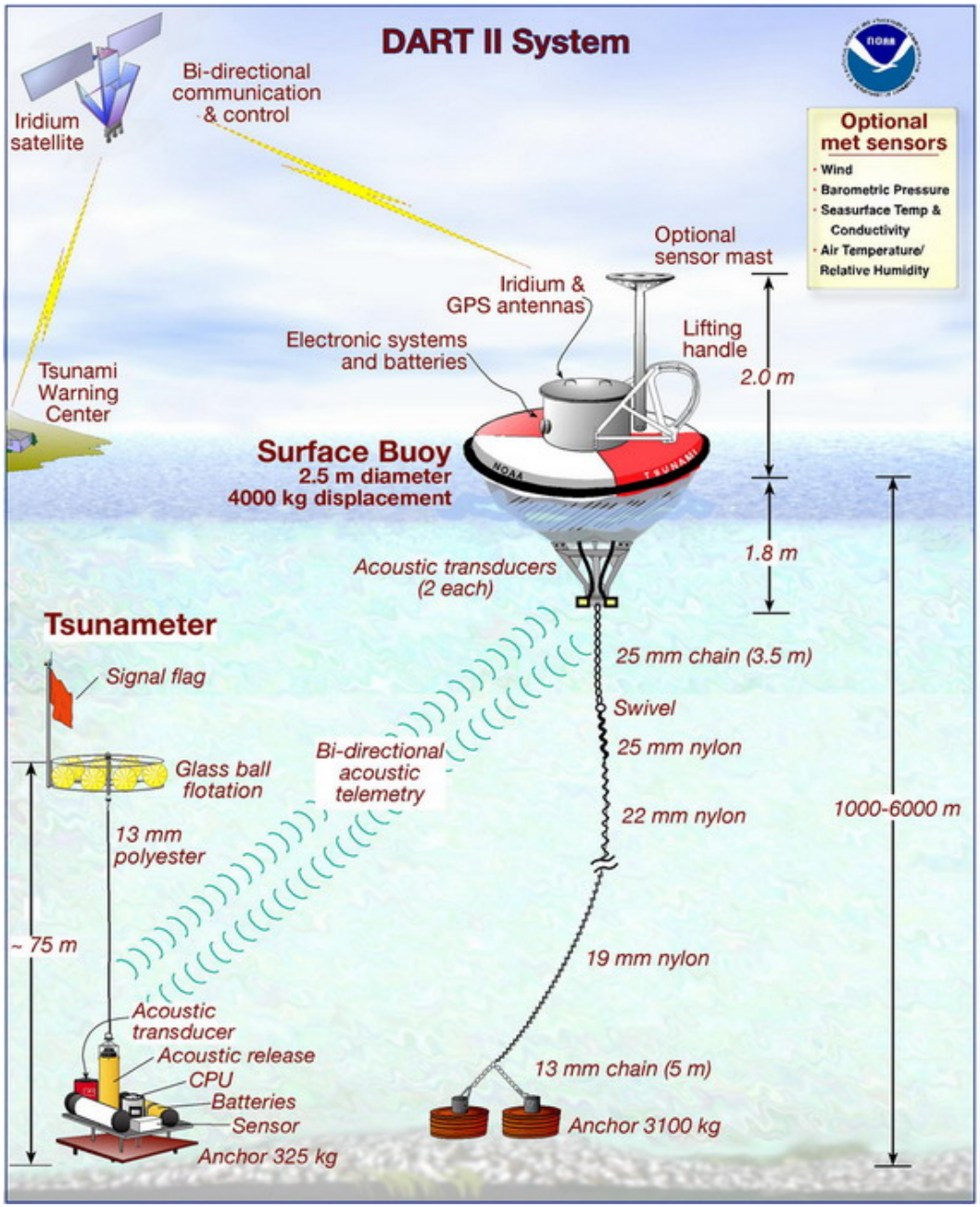
USAID FROM THE AMERICAN PEOPLE | ASIA

Deep-ocean Assessment and Reporting of Tsunami (DART) History

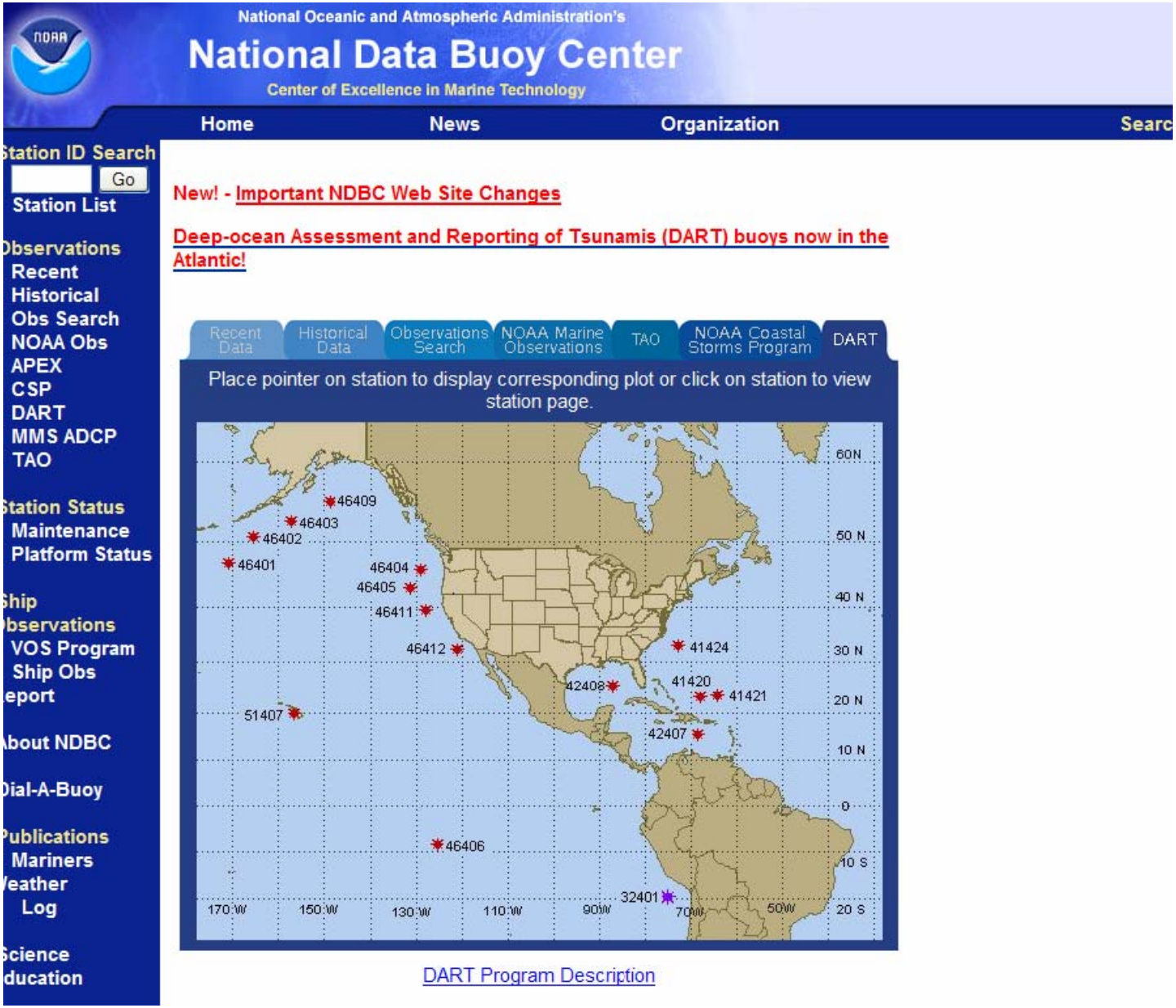
- US has invested in research and development of DART technology since 1990
- First generation DART (one way real-time reporting via GOES satellite) became operational in 2002
- Second generation DART II (two-way real-time reporting via Iridium satellites) became operational in 2005
- Technical details of DART II were placed on web site in June 2005 to share technology with world
- Within 1 year, commercial DART II –like products were brought to market by Fugro and Sonardyne
- DART II (easy to deploy) research prototype deployed in 2006, funds available for further development


DART II System
Iridium satellite
Bi-directional communication & control
Optional met sensors
Wind
Barometric Pressure
Seasurface Temp & Conductivity
Air Temperature/ Relative Humidity
Optional sensor mast
Iridium & GPS antennas
Lifting handle
Electronic systems and batteries
2.0 m
Tsunami Warning Center
Surface Buoy
2.5 m diameter
4000 kg displacement
1.8 m
Acoustic transducers (2 each)
Tsunameter
25 mm chain (3.5 m)
Signal flag
Swivel
25 mm nylon
Bi-directional acoustic telemetry
Glass ball flotation
22 mm nylon
1000-6000 m
13 mm polyester
~ 75 m
19 mm nylon
Acoustic transducer
Acoustic release
CPU
Batteries
Sensor
13 mm chain (5 m)
Anchor 325 kg
Anchor 3100 kg

Update on DART Developments

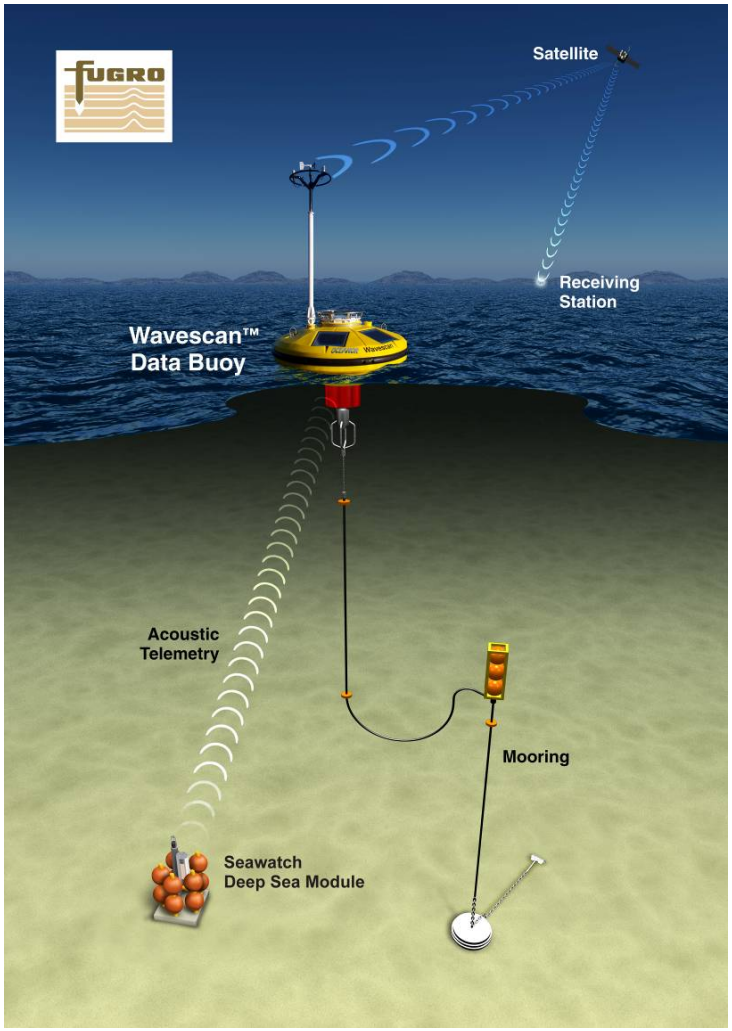
- US has 15 DARTs deployed
- Fugro (Norway) has developed a commercial DART-like systems; SAIC, Vaisala, Sonardyne (U.K.) others have systems in development
- Fugro has one deployed off Banda Aceh
- Germany has deployed a DART-like system off Indonesia
- US has made progress on next generation DART technology: Easy to Deploy

US Tsunami Program now has 15 DART II Systems Deployed



Fugro/Oceanor

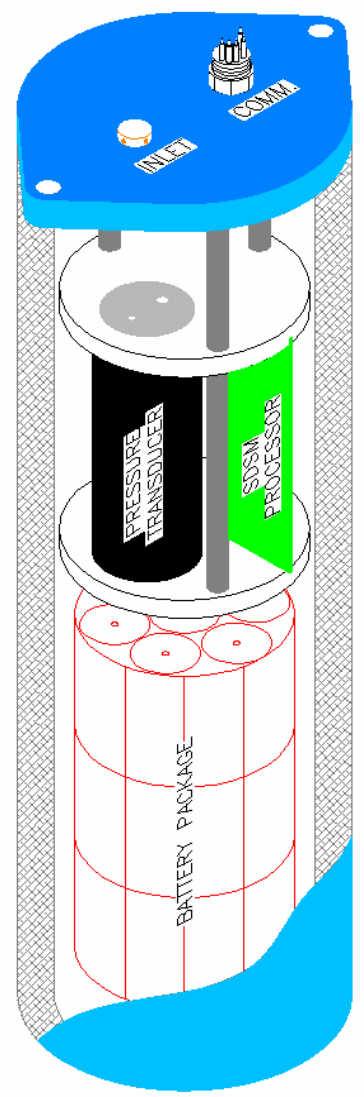
SeaWatch Tsunami Surveillance



- The SeaWatch Deep Sea Module (SDSM), the most recent enhancement to the SeaWatch system
- In line with IOC/WMO recommendations including:
  - System functionality
  - Technical specifications
  - Certification
- Continuously measures the pressure on the sea floor

- Every 15 seconds:
  - Calculates water depth from the pressure measurements using standard formulae
  - Compares the last measured value to a forecasted value. The forecast is calculated statistically from previous measurements
  - If the difference is over a preset limit, the SDSM will switch into alarm mode and transmit the measurements every 15 seconds for a minimum of 3 hours

SeaWatch Deep Sea Module (SDSM)



Specifications

Meas. period:	15 s
Sensitivity:	0.001 meters
Processing:	Tidal variation eliminating algorithm with adjustable threshold (typically ~cm)
Range:	700, 1400, 2100, 4200 or 6000 meters
Material:	Duplex steel, designed for 6000 m depth
Data transmission:	140 – 2400 bits/s acoustic
Battery capacity:	2 years, alkaline batteries

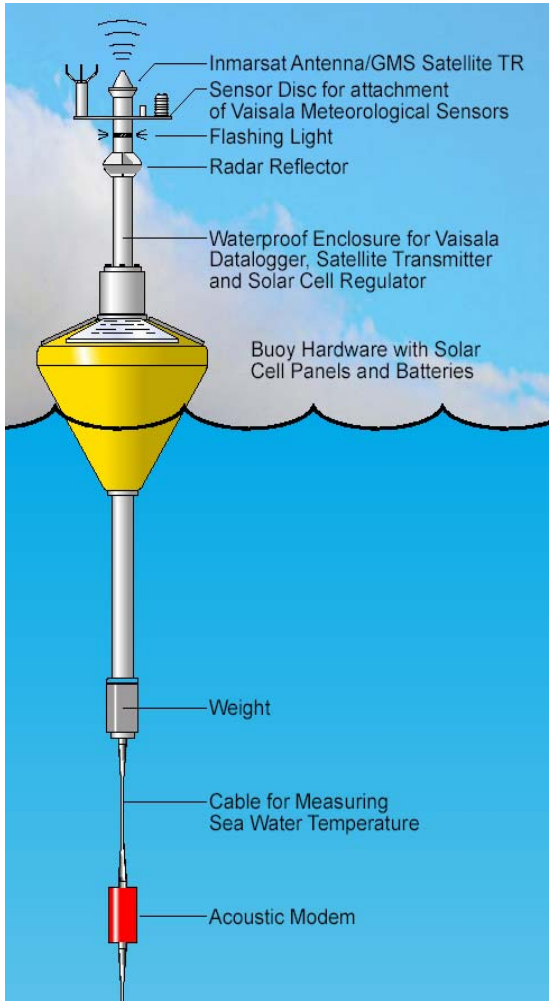
Additional seabed sensors possible

Buoy deployment off Banda Aceh

Vaisala/Aanderaa/Benthos

Surface Buoy Construction key features

- Surface Buoy Construction is built to move vertically in extreme weather conditions
- Key features for ”cone-shaped” buoy with low center of gravity.
  - Limit pitch and roll
  - Buoy moving vertically (up and down in wave and storm events)
- Higher stability in buoy providing:
  - Accurate Meteorological data
  - Low and Stable acoustic communication
- Configured to handle one (1) atmospheres pressure of water (10 meter), if dragged below sea surface during extraordinary events.



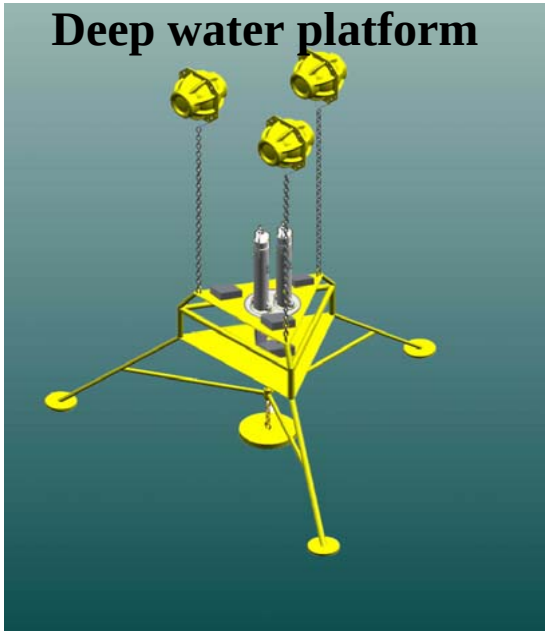
Surface Buoy Construction key features, continued

- Battery Bank of 160Ah and 5 x 24W Solar Panels (with regulator)
- Radar reflector; Blinking light (flashing light), Programmable IALA sequence
- Easy access for service of equipment located in watertight compartments
- Polyethylene flotation with counter weight:
  - Buoy flotation hardware will stay floating even if the polyethylene shell is punctured after collision with a sharp object.
- Material used for surface buoy
  - Titanium for subsurface connectors and metallic structure
  - Hard anodized seawater aluminum and titanium for above surface construction.
- 15 years with experience in high wave conditions surviving Typhoons and the north sea with waves up to 30 meter+

Deep Sea Bottom Package: proven & improved technology from NOAA DART

- Pressure Sensor is Paroscientific Quartz Pressure sensor 4000 series
- Tilt Sensor technology; same as used by NOAA
- Benthos acoustic data communications, used on Dart system by NOAA
  - Improved to include Gimble System
  - Improved to use the new 60Deg communication transducer (16-21kHz)
- Benthos Acoustic release system used by NOAA

Deep water platform



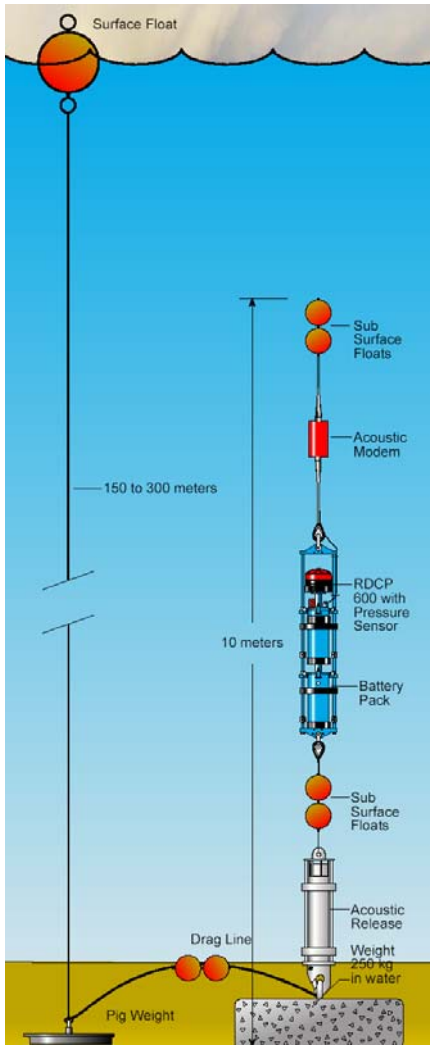
Paroscientific Pressure Sensor, Series 4000

Benthos

Acoustic Release and Modem

1. Fully functional modem
2. Mechanical release
3. 12000 m depth
4. 5000kg load
5. Supports 1-2 RS232

Bottom package for shallow waters; RDCP600



RDCP 600 is equipped with a high accuracy pressure sensor with resolution of 0.20 cm.

- Water level is logged constantly at 2Hz and transmitted every 5 minutes to the surface
- Using standard proven technology that measured Tsunami in Dec. 2004 outside the cost of India
- The system is remotely controlled from a main control center on-shore
- Reprogramming of new sampling interval can be done via satellite and acoustic links

The system provide several parameters to indicate a tsunami wave movement:

- Pressure sensor giving pressure (tide) data detecting abnormal pressure (tides)
- Bottom current direction (and speed) detecting abnormal current directions and speeds
- Tilt sensor detecting abnormal instrumentation tilt (movement)

All these parameters are likely to change if a tsunami occurs

- see separate presentation on the actual measurement data sampled during Tsunami December 2004

Maintenance and Service of the Buoy System

- Light weight and Compact design => Smaller boat can be used for deployment and recovery
  - 20-35 meter boat with crane for 2 metric ton and winch system for 2 metric ton
- Modular Design => Sections of buoy can be serviced separately
- All cables and wiring are inside the buoy => Can not be cut or damaged
- Structure is angled and Solar Cell are incorporated in structure => Fishermen and mammals can not “walk” on buoy.
- Batteries are designed to last for 5 years => Replace battery pack only every 5 years
- Antifouling is painted on buoy and cables; Repaint the buoy every 12-18 months
- Buoy is built to be dragged under 10 meter => Can survive extreme conditions without need for repair
- Acoustic receiver is installed 20 meter under the sea surface => Less biofouling and needs for maintenance

SAIC

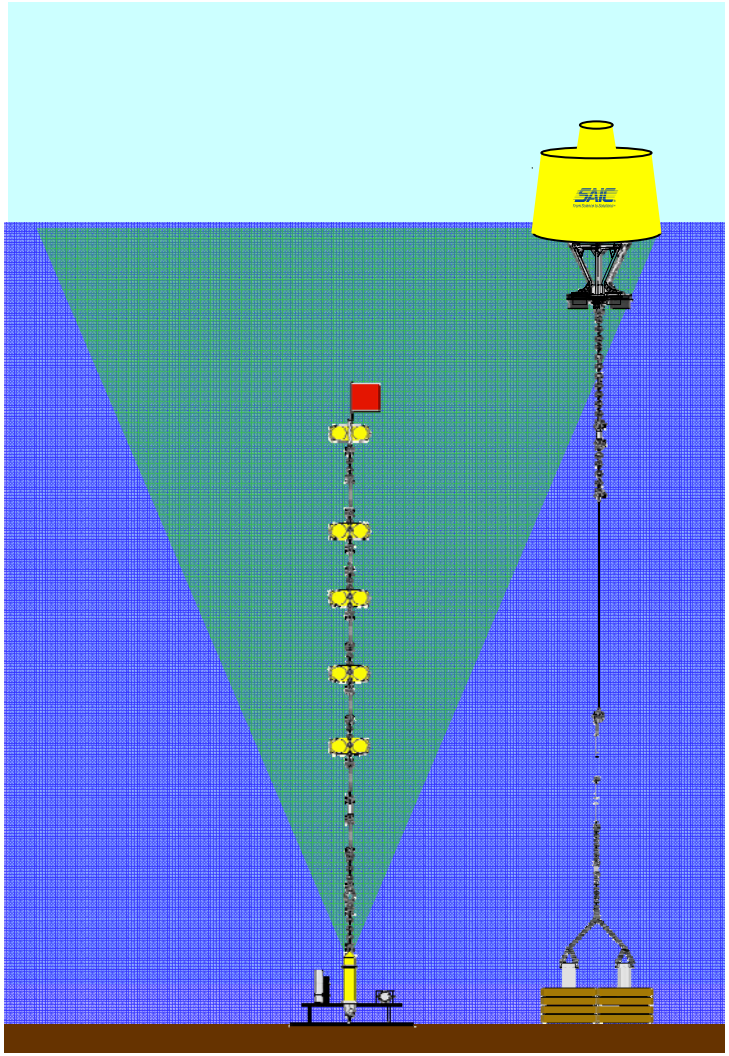
SAIC Tsunami System Capabilities

- **SAIC Provides Engineering Support And Builds The DART II System For NOAA At NDBC**
- **SAIC Designs And Builds Multi-sensor Buoys & Cabled Systems For Other Government Agencies**

SAIC®
From Science to Solutions™

MULTI-HAZARD BUOYS AND WARNING SYSTEMS

- Design
- Integration
  - Sensors
  - Processing
  - Communications
  - Power
  - Mooring
- Production
- Deployment
- Maintenance
- Integrated Logistics System
- Data Management and Data Fusion
- Modeling
- Consequence Assessment
- Command / Disaster Warning Centers



SAIC®
From Science to Solutions™

SAIC Buoy Design Features

Improved DART II Design

Buoy Hull

• New Foam Hull with embedded metallic framework
• Painting not required due to integral color pigment, no void air tests – minimal maintenance
• Excellent resistance to environmental agents, includes UV Resistant top layer, self-fendering with improved ability to withstand damage
• Foam is closed cell with minimal absorption of water even if exterior surface is damaged

Electronics Buoy Well

• Removable Well for easier maintenance.

Electronics

•Simplified circuitry
•Separate redundant electronic enclosures; interchangeable

Batteries

• Higher power density, larger voltage potential per cell and increased life cycle.

SAIC Design Advantages

- Longer hull life
- Greater reserve buoyancy
- Simpler design, less expensive construction
- Expandability
- Less maintenance
- More rapid construction
- Easier shipment and deployment
- More COTS hardware components

Sonardyne (UK)

Latest News

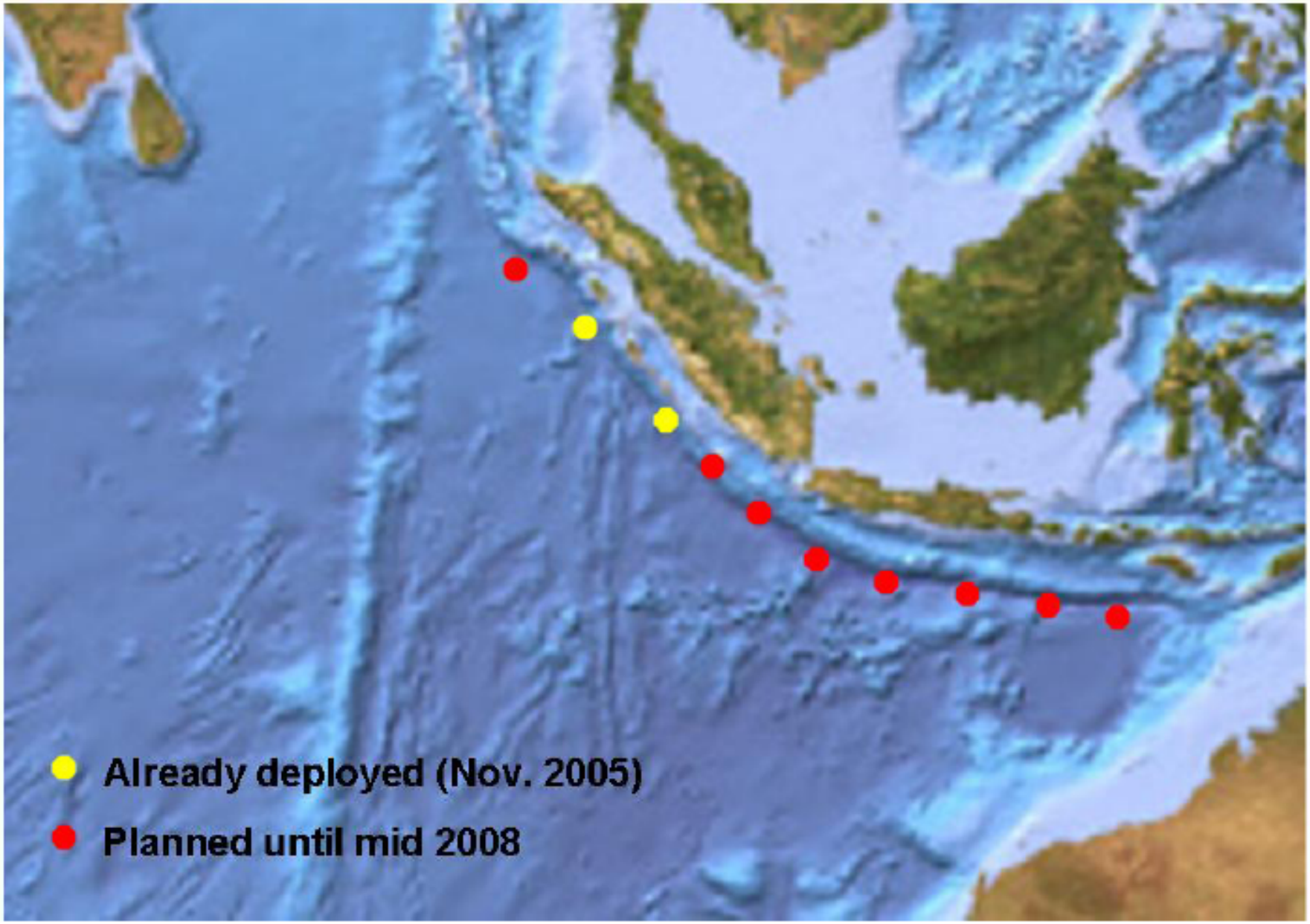
March 2006

Sonardyne launches Tsunami Detection System

A dependable system for providing advance warning of tsunami waves has been developed by Sonardyne International Ltd of Yateley, UK. The company is a world leader in subsea acoustic communications technology and the new system was first presented on Sonardynes stand at the Oceanology International '06 Exhibition, London.

Germany/Indonesia Partnership

Indonesian-German TEWS
Buoy Positions



DART II Easy-to-Deploy

DART II Easy-to-Deploy Design Goals

- Meet science requirements for detection
- Low cost – acquisitions, deployments, support
- Vandal resistant
- Long life
- “Factory built” - exportable design
- Deep water, high latitude capable
- Simplified deployments
- Decreased ship requirements
- Safety at sea


Anchor
Reel with 5000 meters of mooring line
SST
Barometric Pressure
Acoustic Modem Transducer
Wind Sensor
Tsunameter
DART
OCEAN EXPLORATION
NOAA PMEL
PMEL -Engineering Development Division Seattle, WA


DART
NOAA
PMEL
PMEL -Engineering Development Division Seattle, WA

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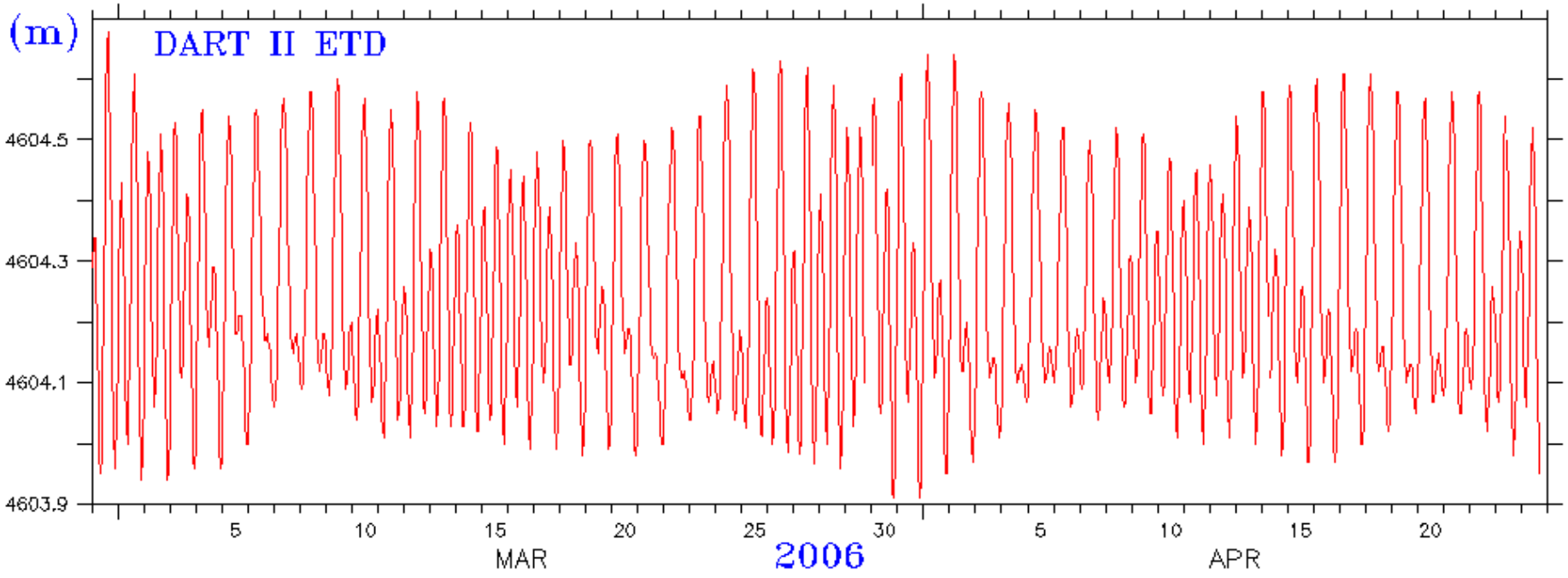
DART II Easy To Deploy :
Current test off Hawaii indicates
99.3% data return
for the past 60 day period,
accurate detection of Tonga tsunami



What's Next

- Need for affordable, reliable tsunami detection systems world-wide
- Expect many qualified suppliers
- Standards and protocols critical for
  - Quality assurance
  - interoperability